Closing material loops: The case of plastic recycling from household waste

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Background and aim

The concept of **circular economy** has been presented as a measure to mitigate resource depletion and ensure sustainable development. Plastic has been chosen as focus area in the European strategy towards a circular economy, with emphasis on recycling of plastic from household waste.

The quality of the secondary plastic produced from recycling is important for the circularity, since recycling of plastic from household waste into low quality material will result in downcycling of the part of the plastic waste that previously was of high quality (food contact material). Downcycling happens because **plastic from household waste (HHW) is a contaminated and heterogeneous waste stream and recycling of plastic from HHW to low quality material is therefore common** with current recycling technologies. Consequently, the demand for virgin plastic for high quality applications (e.g. food packaging) is not prevented. As a result, **recycling rates need to be supplemented by a measure of quality in order to sufficiently express the circularity** and the actual degree to which the plastic loop is closed.

The **aim** of this study was to **assess the quality of recycled plastic from HHW**, based on physical and chemical properties, and provide understanding of how the different steps of plastic recycling influences the quality.

Method: Scenarios and quality assessment

87 plastic recycling scenarios were defined by combining a range of realistic options in four scenario modules, as presented below:

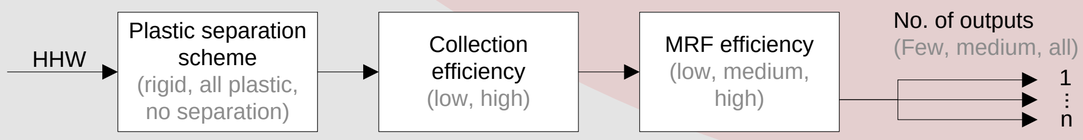

Figure 1: Flow diagram of the scenario modules. The scenarios start when HHW is generated and stops when outputs prepared for recycling leave the MRF. Possible outputs are PET, HDPE, PP, PS, film and mixed plastic. MRF: Material recovery facility.

A material flow analysis (MFA) was carried out for each scenario to assess the level of contamination of all the outputs produced. The **potential quality/functionality** of the outputs from the MRF was assessed by the method of Vadenbo et al. (2016), by identifying:

- **The technical functionality**: Based on the level of contamination, does the plastic recyclers accept the plastic waste and if so for what quality?
- **The institutionally prescribed functionality**: Does the chemical composition of the plastic waste comply with legal requirements?

Results and discussion: Quality of recycled plastic from household waste

- With the current recycling systems in Europe only **PET** and **HDPE** has a potential to be recycled into **high quality** material (at present in Europe only PET is approved for recycling into high quality).
- Only scenarios with high performing and in few cases medium performing MRF's can produce high quality PET.
- Systems where only **rigid plastic** items are target in the **separation scheme**, not soft plastic, seems to produce a less contaminated plastic stream and are thereby better schemes for producing high quality recycled plastic.

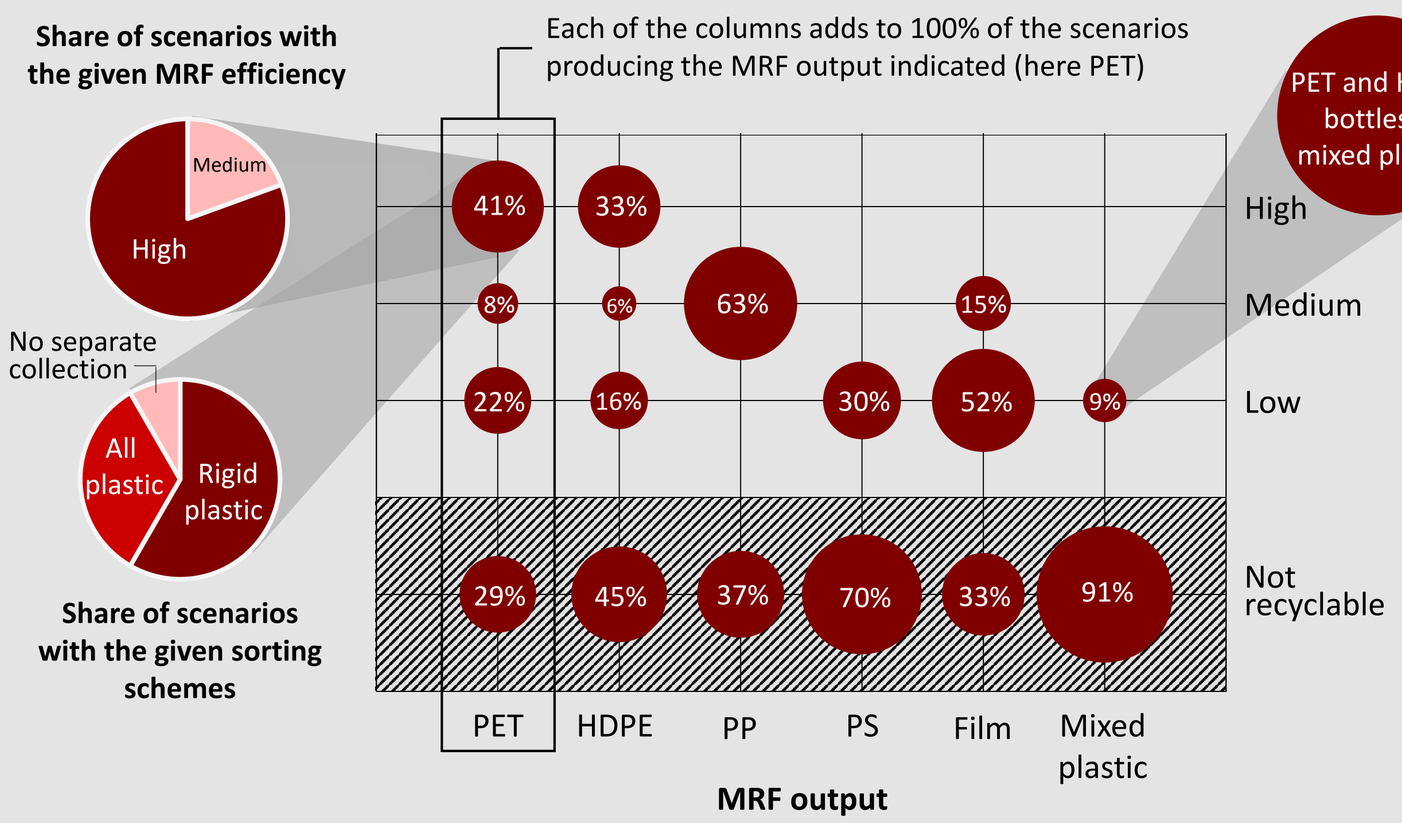

Figure 2: Percentage of scenarios, illustrated by the size of the bubble, where the outputs produced at the MRF has a high, medium or low quality or is not suitable for recycling. The bubbles for each MRF output sums up to 100% of the scenarios, as indicated for PET.

- **PP** and **film** streams were found to have a maximum potential of recycling into **medium quality.**
- **PS** and **mixed plastic** were in most scenarios found entirely unsuitable for recycling. Recycling into **low quality** is the maximum potential for these outputs.
- Only the most simple MRFs with few outputs (PET and HDPE bottles), produced mixed plastic suitable for recycling, as a large share of the high quality products remains in the mixed plastic.

Conclusion

- Only PET and HDPE waste from households has a potential to be recycled into high quality plastic with a potential to substitute virgin plastic in food contact materials..
- Only systems with state of the art MRF and reprocessing facility, approved to produce food grade plastic, has a potential to produce high quality recycled plastic.
- Recycled PP, PS, film and mixed plastic can as a maximum be recycled into medium or low quality plastic
- Most recycling systems produce mixed plastic unsuitable for recycling

References

Vadenbo, C., Hellweg, S., Astrup, T. F., 2016. Let's be clear(er) about substitution – a reporting framework to account for product displacement in Life Cycle Assessment. Journal of In-dustrial Ecology. DOI: 10.1111/jiec.12519

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